Gating Verification via Correlation of Dynamic DRRs and Respiration-Correlated MV Fluoroscopic Images

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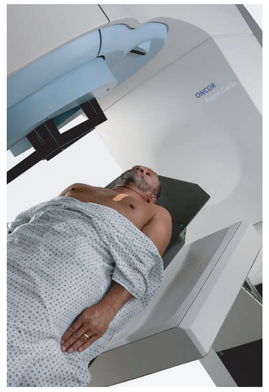
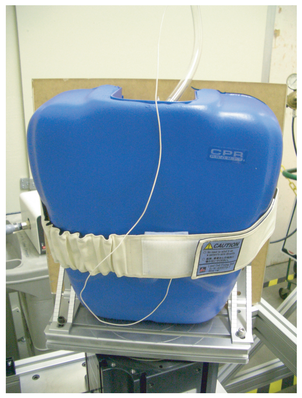
Objective

To demonstrate the practicality of low-dose megavoltage (MV) fluoroscopic imaging for dynamic treatment plan verification and respiratory gating adjustment.

A treatment linac is modified to provide a low dose fluroscopic mode





A custom pneumatically-actuated, computer-controlled anthropomorphic torso phantom is used to obtain kV planning and MV fluroscopic images. Simulated respiration is measured using a strain gauge-based belt.

Background

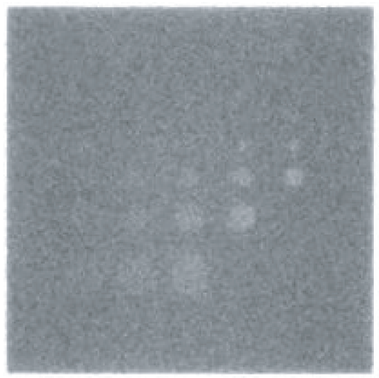
Dynamic treatment plans created from the planning CT assume a tumor assume that the tumor trajectory will not change between planning and therapy. This is unrealistic in respiratory applications, as breathing patterns show high variability.

We show how MV fluoroscopy can be used before each treatment to correct respiratory gating parameters so that the treatment is consistent with the 4D treatment plan.

Methods

A treatment linac, fitted with an MV-optimized flat panel detector, was modified in order to produce fluroscopic images at a dose of 0.02-0.06 cGy per frame at a frame rate of 2 fps. A static torso phantom was imaged to determine whether useful delineation of organs-of-interest could be achieved. Dynamic imaging was evaluated using an anthropomorphic breathing torso phantom fitted with a respiration-sensing belt. The MV image and respiratory force waveforms were simultaneously recorded. A computer application was developed so that treatment digitially reconstructed radiographs (DRRs) derived from a 4D treatment planning CT study can be matched to the current breathing depth and frequency of the patient immediately before treatment.

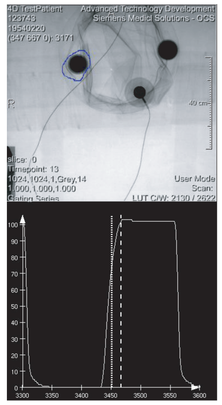
MV fluroscopic image of Las Vegas contrast phantom at a dose of 0.04cGy

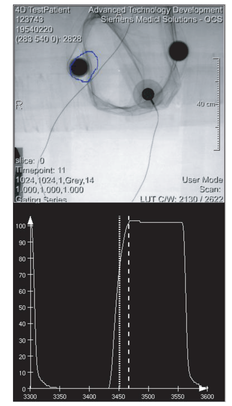


Procedure

1. On DRR derived from planning CT, identify respiratory gate interval during which tumor is within plan contour.

DRR derived from planning CT showing "tumor" position at the selected **beam-on** respiratory gate

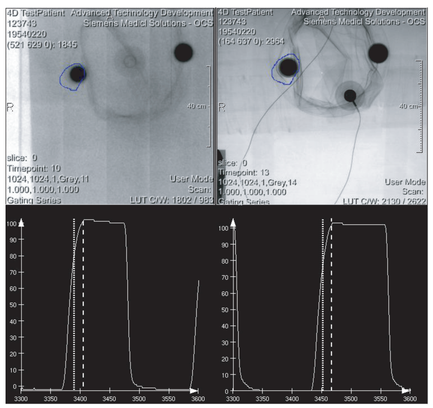




2. Position patient for treatment. Owing to changes in breathing pattern between planning and treatment appointments, the chosen gates will be inappropriate at treatment:

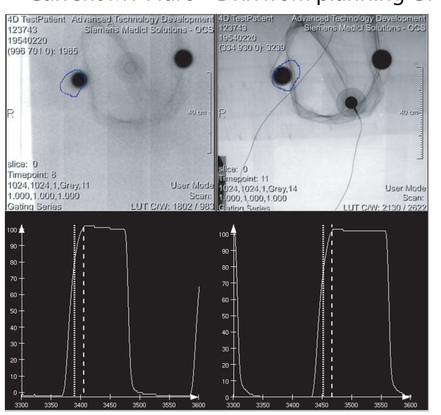
Beam-on gate

Current MV Fluro DRR from planning CT

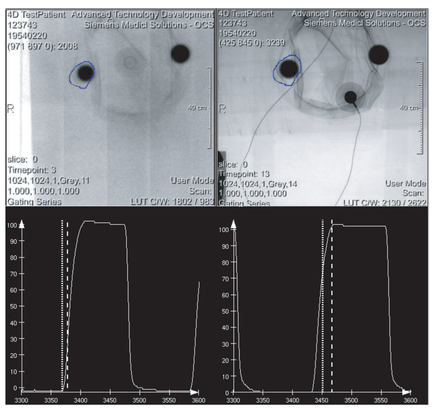


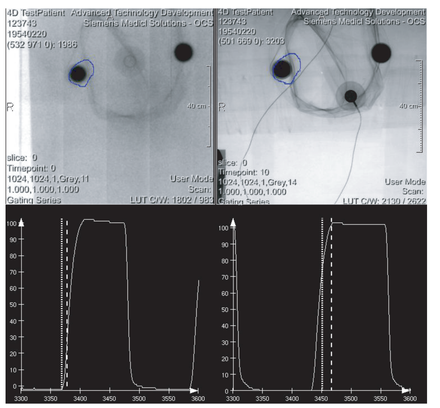
Beam-off gate

Current MV Fluro DRR from planning CT



When the same gate positions are used, tumor position is inconsistent with plan.





The gate adjustment tool allows for rapid modification of the gate positions to restore consistency with the treatment plan.

Conclusion

We have demonstrated how low-dose MV fluroscopy may be employed for 4D treatment plan adjustment in respiratory-gated treatment delivery using a simple imaging tool.